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NIST Handbook 105-8
Field Standard Weight Carts
Draft 3

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SPECIFICATIONS AND TOLERANCES FOR FIELD STANDARD WEIGHT CARTS

INTRODUCTION

A field standard weight cart (after this, simply called "weight cart") is intended to be used in conjunction with Class F weights for the testing of commercial weighing devices for compliance with the requirements of NIST Handbook 44. The combination of Class F weights and weight cart may be used to test scales of class III L with a 'd' equal to or greater than 5 lb, class IV, and scales not marked with a class description. Before using a weight cart, compliance with the requirements of NIST Handbook 44, Appendix A, Section 3, "Testing Apparatus" must be evaluated. Handbook 44, Appendix A, Section 3 establishes the requirements for the standards used in legal metrology, including a statement that the maximum error of an uncorrected standard should not exceed 1/3 of the allowable tolerance for the device tested.

Key words: Retroactivity, weights and measures, specifications, standards, tolerances,

1 Scope

1.1 'Field Standard' Classification

These specifications are limited to motorized weight carts used in conjunction with NIST Handbook 105-1, Class F test weights. Weight carts are NOT considered NIST Class F Field Standards. This handbook does not apply to railroad test cars or non-motorized weight baskets.

1.2 Retroactivity

These specifications apply to new weight carts manufactured after January 1, 2004.

A weight cart in service before the publication of this standard that maintains tolerance between verification tests shall continue to be acceptable, though some modifications may be required for continued acceptability under this standard. All weight carts in service must comply with those specifications that have an asterisk (*) following the title. These include the requirements addressing tires, batteries, tolerances and fuel tanks. Existing components that comply with the requirements are acceptable for continued use. Weight carts in service at the time of this publication that do not conform to required sections, must have modifications completed before December 31, 2005.

Weights and measures jurisdictions may require that a weight cart comply with non-retroactive specifications, if required to maintain a weight cart within tolerance. Weight carts that do not maintain the specified tolerance shall be removed from service until modifications are performed that enable the weight cart to maintain tolerance.

1.3 Safety Considerations

The use of weight carts may involve hazardous materials, conditions, operations and equipment. This document does not purport to address the safety problems associated with weight cart use.

Known hazards may include, but are not limited to:

- The handling of petroleum products,
- The handling and connection or disconnection of energized electrical cables,
- The use, maintenance and disposal of various types of batteries,
- Handling of large weights, and
- Possible exposure to carbon monoxide gas from gasoline engine exhaust.

It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability for regulatory limitations prior to use.

1.4 Units

The majority of scales tested with weight carts indicate mass values in U.S. Customary units. Petroleum products used in weight carts have a 60 °F (15 °C) reference temperature. Therefore, this publication primarily uses U.S. Customary units due to the needs of industry and regulators. Metric equivalents are provided when the likelihood exists that they may be used. Metric equivalent values provided may not be exact conversions but are provided as convenient alternative values that will not have adverse impact on the quality of the calibrated product.

2 Reference Documents

2.1 NIST¹

Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, see current edition, published annually.

Handbook 105-1, Specifications and Tolerances for Field Standard Weights (NIST Class F).

2.2 NCWM²

Publication 3, NCWM Policy and Guidelines, Section 3.2.15, 1991.

Publication 12, Examination Procedure Outlines for Weighing and Measuring Devices

Publication 14, National Type Evaluation Program, (NTEP) Administrative Procedures, Technical Policy, Checklists, and Test Procedures, see current edition, published annually.

3 Terminology

Class F Field Standard Weight. A weight meeting NIST Handbook 105-1 design and tolerance criteria for field standards.

1. NIST, National Institute of Standards and Technology

2. NCWM, National Conference on Weights and Measures

Field Standard. The term “field standard” means the physical standards that meet specifications and tolerances in NIST 105-series handbooks (where available) and are traceable to the primary or secondary standards through comparisons, using acceptable laboratory procedures.

Tolerance. Maximum permissible error. A value fixing the limit of allowable error or departure from the true performance or value.

Weight cart. A field standard test weight meeting the requirements of NIST Handbook 105-8 used both as a field standard weight and as the means of moving other field standard weights before, during and after, large capacity scale tests.

4 General Specifications

4.1 Weight

4.1.1 Nominal empty weight

Weight carts shall be constructed in one of the following 500 lb increments: 2000 lb, 2500 lb, 3000 lb, 3500 lb, 4000 lb, 4500 lb, 5000 lb, 5500 lb or 6000 lb.

The weight cart, with the adjustment cavity empty and all fluid levels adjusted to the reference levels, shall weigh a minimum of 50 lb and a maximum of 100 lb less than the nominal empty weight.

Adjustment material sufficient to bring the weight cart to nominal mass will be supplied with each weight cart.

4.1.2 Weight and Size Limitations

Local weights and measures jurisdictions may have use, size or weight restrictions on weight carts. Approval of use, size and weight must be obtained from the weights and measures jurisdiction(s) in which weight cart use is planned. Coordination between the purchaser and the supporting calibration laboratory, before purchase, is essential to ensure that the laboratory can provide a proper calibration.

4.2 Materials

A weight cart body and frame shall be of steel construction. Other durable and stable materials may be developed, but approval for use of such materials must be obtained from the NIST Office of Weights and Measures prior to implementation as a construction material.

Rubber hoses may be utilized for fluid transfer where flexible connections are needed, but should be kept to a minimum. Metallic tubing is to be used where possible to minimize use of rubber hoses.

4.3 Workmanship, Finish, and Appearance

All edges and corners shall be smooth, with no sharp edges, to prevent injury during routine use and maintenance. All surfaces shall be free of slag, scale and weld splatter, grit, dirt, or any foreign matter before shipment from the factory or before submission for calibration.

Unless constructed of corrosion resistant materials, all exposed surfaces shall have a protective surface coating. The coating must be a high quality material having the following properties: corrosion inhibiting, non-hygroscopic, chip and abrasion resistant, smooth surface. Flat aluminum paint or flat lacquer finishes are preferred.

4.4 Design

Representative designs are shown in figure 1; variations in design are permitted. Prior to production, manufacturers should seek design approval from NIST Office of Weights and Measures. 'Design approval' applies only to the size and suitability of the cart as a test weight in the calibration of large capacity scales, and does not imply in any way design approval for structural strength and integrity.

4.5 Identification Plate

4.5.1 Placement

Each weight cart shall have an identification plate mounted in a conspicuous and easily accessible place near the operator controls.

4.5.2 Content

The identification plate shall contain the following items in clear permanent text in a font size no smaller than 0.1 inch x 0.1 inch (2.5 mm by 2.5 mm).

- nominal empty weight of the cart;
- maximum gross weight;
- name and address of the manufacturer;
- manufacturer's model number;
- manufacturer's non-repetitive serial or identification number;
- date of manufacture;
- statement of compliance with this specification including the revision in effect at time of manufacture; and
- additional information that the manufacturer may deem necessary.

4.6 Power

Weight carts may be powered by an electric motor (battery or generator driven), or liquid fueled engine. Power may be transmitted to the wheels by either fluid or mechanical coupling methods.

4.7 Fuel Tank *

4.7.1 Fuel Tank Capacity

Liquid fueled weight carts shall have a maximum fuel capacity of 231 cubic inches (3785 cm³). A sample drawing of a suitable fuel tank design is found in Attachment 1. The fuel tank shall have the general shape of a right circular cylinder and shall comply with all applicable federal specifications. The top of the fuel tank shall not extend above the plane described by the top edge of the weight restraint system.

4.7.2

4.7.3 Fuel Tank Fluid Level Indicator

For liquid fueled weight carts, a suitable glass sight gauge with a marked reference level near the top of the fuel tank is required. The sight gauge shall be positioned so that the operator can

easily view it during weight cart operation. Fuel level markings corresponding to ½ lb increments shall be placed below the reference level mark over the length of the sight gauge. The distance between the markings shall be established based on the fuel tank cross-sectional area and the API table value for the recommended fuel.

4.7.3.1 Fuel Level Error Weights

The manufacturer of the weight cart shall supply fourteen ½ lb error weights in a box that is separate from the weight cart.

A means shall be provided whereby the operator can easily and securely attach ½ lb error weights to the weight cart to compensate for weight lost due to expended liquid fuel. The error weights shall be placed on the weight cart only to compensate for expended fuel.

4.7.4 Cross Sectional Area of Tank

The combined cross sectional area of the fuel tank and sight gauge must be no greater than 12.5 square inches (81 cm²) at the reference level.

4.7.5 Fuel Tank Color and Finish

The fuel tank shall be a light color to minimize heating of the fuel by radiant heat sources. Any plating or paint materials shall not be degraded by contact with the fuel. A natural stainless steel color is acceptable.

4.7.6 Fuel Tank Drain

If equipped with a fuel tank drain apparatus, the drain assembly must extend past the edge of any nearby weight cart structure.

4.8 Hydraulic Fluid System

4.8.1 Hydraulic Fluid Reservoir Fluid Level Indicator

Weight carts equipped with a hydraulic reservoir must have a sight gauge, with a clearly marked reference level, for maintaining hydraulic fluid levels. The fluid level must be visible under all operational conditions. The hydraulic reservoir shall have sufficient expansion capacity so that no hydraulic fluid will be lost during normal use. The fluid level shall be adjusted to the reference level with the hydraulic fluid temperature at calibration laboratory conditions.

4.8.2 Hydraulic Fluid Reservoir Fluid Fill and Drain Tamper Indicators

The fill and drain caps of the hydraulic reservoir shall be equipped so that a lead and wire seal can be installed to indicate tampering with or adjustment of the hydraulic fluid level.

Tampering or adjustment requires that the weight cart be submitted for re-calibration prior to use as a weight standard.

4.8.3 Hydraulic Fluid Reservoir Fluid Drain System

If equipped with a hydraulic fluid reservoir drain apparatus, the drain assembly must extend past the edge of any nearby weight cart structure.

4.8.4 Hydraulic Fluid Filtration System

The hydraulic fluid filter system shall be positioned, or a suitable means developed, so that removal does not cause oily contamination of any fixed cart surfaces.

4.9 Engine Lubricating Oil System

4.9.1 Engine Lubricating Oil Reservoir Reference Level

The lubricating oil reservoir of the weight cart engine shall be maintained at the reference level established by the engine manufacturer using the recommended lubricating oil type. The lubricating oil level shall be adjusted, prior to calibration or use, to the reference level with the oil temperature at calibration laboratory conditions. The engine must not have been operated for a period of at least 4 hours immediately prior to adjusting the engine oil level. Severe contamination by fuel or combustion deposits shall require that the lubricating oil be replaced and that the cart be re-calibrated.

4.9.2 Engine Lubricating Oil Reservoir Drain System

If equipped with a lubricating oil reservoir drain apparatus, the drain assembly must extend past the edge of any nearby weight cart structure.

4.9.3 Engine Lubricating Oil Filter

The engine oil filter shall be positioned, or a suitable means developed, so that removal does not cause oil contamination of any fixed cart surfaces.

4.10 Engine exhaust

The exhaust pipe(s) shall be positioned and/or shielded so that they are not contacted by the operator during normal weight cart operation. Exhaust gasses shall exit the exhaust pipe(s) in a horizontal direction and not be directed toward the operator control station.

4.11 Tires *

4.11.1 Size and Number

Tire size and quantity shall be chosen to prevent overloading of scale platforms. The contact area of the tires to the supporting surface shall cause no point load concentrations in excess of 200 lb/in² (1.38 MPa) when loaded to the maximum gross weight of the weight cart.

4.11.2 Tire Tread Pattern

Weight cart tires surfaces shall be smooth (without tread) and have no major cuts or deformations.

4.12 Wheel Bearings

Axle bearing/hub assemblies should not require routine lubrication. Where possible, the use of pre-lubricated sealed bearings is recommended. Bearing units requiring liquid lubricants are not permitted.

4.13 Minimum Wheel base and Track dimensions

The weight cart shall be designed so that the center of gravity in any loading configuration shall not cause the weight cart to become unstable on slopes normally encountered during scale

testing.

4.14 Drainage

Weight carts shall be designed to prevent the pooling of water on weight cart surfaces. Horizontal surfaces of the cart must be constructed of a single layer of material to prevent weight instability caused by trapped water layers.

4.15 Weight Restraint

The railing around the deck of the cart shall be of sufficient strength and height to restrain the test weights being transported during testing and shall be permanently attached to the weight cart.

4.16 Weight Cart Transport

It is strongly recommended that weight carts be transported in an enclosed truck body to prevent contamination of the weight cart. As a minimum, the weight cart shall be covered by a suitable waterproof covering during transport. The weight cart shall have provision to be securely fastened to the transporting vehicle while being transported.

4.17 Lifting Attach Points

4.17.1 Lifting Attach Points Purpose

The weight cart shall be equipped with a means of lifting the empty weight cart onto a transport vehicle and onto a scale or balance for calibration.

4.17.2 Weight Cart Balance

The empty weight cart shall balance in an approximately level position when lifted by the means proscribed by the manufacturer.

4.18 Adjustment Cavities

Weight carts shall be designed with one or more adjustment cavities. Multiple adjustment cavities are permitted when required for adjusting the balance of the weight cart when lift in the manner proscribed by the manufacturer. Adjustment cavities must be water tight.

4.18.1 Cavity capacity

Weight cart adjustment cavities shall have a minimum total capacity of approximately 150 lb of adjustment material.

4.18.2 Adjustment Cavity Mounting

Adjustment cavities must be removable for performing weight adjustment activities. Adjustment cavities shall be securely attached to the main weight cart structure in such a manner that a lead and wire seal or other suitable seal can be installed to indicate tampering.

4.18.3 Adjustment Cavity opening(s)

Adjustment cavity opening(s) shall be easily accessible, sufficiently large and positioned to facilitate the insertion and removal of adjustment materials. Adjustment cavity openings shall be water tight.

Each adjustment cavity opening shall have provision for sealing with a lead and wire seal, or other suitable seal.

4.18.4 Adjustment material

Any metal in the form of shot or solid pieces may be used to adjust the weight of the cart. Lead or steel shot is preferred.

4.19 Brakes

4.19.1 Service Brake

Weight carts shall be designed with a braking device or system that allows the operator to restrain the fully loaded cart when descending slopes, and to bring the weight cart to a smooth stop when desired. The service brake must maintain the weight cart in position until released by the operator.

4.19.2 Parking Brake

Weight carts shall be designed with a parking brake that engages automatically when the engine stops to prevent undesirable weight cart motion, or that the operator may engage manually. The parking brake must be capable of restraining the cart at the maximum gross weight under normal operating conditions.

The parking brake and service brakes may be one and the same, provided both functions are performed.

4.20 Directional controls

All operator controls shall function in a manner consistent with the desired direction of travel. The weight cart shall respond to operator input by moving in the direction in which the control mechanism is moved.

4.21 Battery *

Batteries used to provide power to the motor for starting or propulsion shall be of the sealed lead acid type. The battery shall be placed for ease of maintenance and have a means of installing a lead and wire seal to indicate tampering, adjustment or replacement. The lead and wire seal must be placed to allow safety inspections and routine maintenance such as terminal cleaning. Replacement of the battery requires that the weight cart be submitted for re-calibration.

4.22 Battery Charging Circuit

The battery charging circuit shall regulate the charging voltage and current at a level suitable for the battery in use to avoid mass instabilities caused by venting through the battery case relief mechanism.

4.23 Routine Lubrication

All lubrication points must be accessible from a safe location around the cart. Routine maintenance shall not require an operator to move about under a suspended weight cart. The design shall allow easy removal of excess or displaced lubricant after servicing.

4.24 Electrical Power Connections

Electrical power required by weight carts with electric motors shall be supplied via a detachable power cord from either a truck mounted generation system or from facility power. The power connections shall be made using electrical connectors that are Underwriters Laboratories approved and shall conform to local electrical code. It is recommended that electrical code requirements be investigated prior to manufacture of the cart.

Only those electrical connectors mounted permanently to the weight cart structure shall be included in the calibrated mass of the weight cart. All removable electrical connectors shall be removed during calibration and at any time when the calibrated mass of the weight cart is required.

Any upgrades or changes required by local electrical code changes will require that the weight cart be submitted for re-calibration prior to use.

4.25 Remote Operation

Remote operation of the weight cart may require the addition of actuators and RF receiving units. The installation of such components shall not interfere with compliance with this handbook.

5 Tolerances *

The tolerances in Table 1 are the maximum allowed if the standard is to be used without correction in scale testing applications. Weight carts should be adjusted during calibration to nominal values if at all possible. Weight cart tolerances are based on an evaluation of the expanded uncertainty of the scale calibration as compared with one third of the current acceptance tolerance (from NIST Handbook 44 tolerance tables applied to the device being tested). The sum of the maximum allowable error of the weight cart plus the allowable errors of the weights required to perform the test, complies with the Handbook 44 criteria for an acceptance test of a Class IIIIL scale.

Table 1. Tolerances

Nominal Empty Weight (lb)	Weight Cart Tolerance (± lb)
2000	0.50
2500	0.50
3000	1.00
3500	1.00
4000	1.25
4500	1.25
5000	1.50
5500	1.50
6000	2.00

6 Verification Requirements

6.1 Legal requirements

The specifications and tolerances herein specified are intended to permit the use of the equipment in normal field testing operations as standards having nominal values. Weights and measures requirements, including but not limited to, inspection, testing, and sealing, by a NIST OWM Recognized laboratory shall be followed.

NOTE: Some States have requirements not documented here. Check with the local jurisdiction for requirements.

6.2 Initial Verification

A weight cart shall be inspected and calibrated before being placed in service to ensure that the specifications and tolerances of this handbook are met. The calibration status of a weight cart shall be verified as often as required by regulation or circumstance, especially when damage is known or suspected.

6.3 Periodic Calibration

Field standards must be verified prior to use and rechecked as often as regulations or circumstances require, especially when damage is known or suspected or seals are broken. Initial weight cart calibration intervals shall be established at 1-year and extended or reduced based on historical evidence up to the limit determined by State or local regulations. The calibration interval should not exceed 2 years due to the many variable mass components.

6.4 Traceability

Field standards used for legal metrology must be traceable to national standards by calibration in a laboratory recognized by NIST OWM to calibrate in that parameter, range, and scope.

All components of the weight cart that are not an integral part of the structure shall be sealed to the weight cart structure by means of a lead and wire seal or by use of a tamper indicating material. This includes but is not limited to: the battery cover, motor, hydraulic pump, fluid fill caps, drive motors and oil filter. Removal or replacement of items shall be recorded in the maintenance log of the weight cart.

6.5 Calibration Reports

Acceptable accuracy and traceability to national or international standards shall be documented in a calibration report meeting the requirements of NIST Handbook 143, State Weights and Measures Laboratories Program Handbook.

An 'Inspection Checklist' must accompany the Calibration Report for all weight carts. (See sample checklist in NIST Handbook 145, SOP 33, Recommended SOP for Calibration of Weight Carts).

7 Test Methods

7.1 Documented Test Procedure

Calibration of weight carts shall be by an approved NIST procedure, NIST Handbook 145, SOP

33, “Recommended SOP for Calibration of Weight Carts”. Additional requirements may be levied by the jurisdiction in which the weight cart will be used.

8 Uncertainties

Uncertainties of the calibration must be evaluated according to the ISO Guide to the Expression of Uncertainty in Measurement, 1993, to ensure that the three to one accuracy ratio required by NIST Handbook 44 is maintained. The expanded uncertainty ($k=2$) of the calibration must be less than $1/3$ of the tolerance specified for the weight cart being tested.

Typical uncertainty components that should be considered are: scale/balance standard deviation, uncertainty of standards, long term stability of the weight cart and such other measurement influences as may be determined to be significant to the weight cart calibration process.

9 User Requirements

9.1 Use in combination with test weights

A weight cart may be used, alone or in combination with Class F field standard weights, up to the maximum gross weight established by the manufacturer. The user must ensure that the requirements of NIST HB 44 are maintained.

9.2 Weight Cart Maintenance

Any maintenance process performed between scheduled calibrations that may alter the mass of the weight cart invalidates the calibrated mass of the cart and requires that the weight cart be recalibrated. This includes, but is not limited to: replacement of the battery, changing lubricating oil and filter and servicing of the hydraulic system. When “As Found” data is required for reverse traceability, maintenance should be performed after measuring and recording the “As Found” mass of the weight cart. For this test, only the fuel level shall be adjusted. All other fluid levels shall remain as they were when the cart was delivered for calibration. “Final” calibration data shall be recorded after completion of routine maintenance and adjustment of all fluid levels.

9.3 Weight Cart Maintenance Logbook

The organization owning the weight cart shall establish a maintenance logbook containing a detailed record of all maintenance performed on the weight cart. The logbook should document serial numbers of individually serialized weight cart components, e.g. engine, hydraulic pump, battery and drive motors. The logbook will also include copies of all Calibration Reports and completed Inspection Checklists. This logbook shall document the calibration status and history of the weight cart beginning at the time of initial placement in service to the current time of use. The Maintenance Logbook of weight carts placed in service prior to publication of Handbook 105-8 shall begin as of the date of Handbook 105-8 publication and shall include such previous documentation as is available. Documentation of maintenance shall include a description of the maintenance performed, including part numbers where applicable, and when available the weight of items removed from or installed on the weight cart.

9.4 Inspection Checklist Verification

Prior to a scale test, all items on the Inspection Checklist must be evaluated for consistency with conditions at calibration. All fluids must be at the levels recorded at the time of calibration and all tires must be in good condition.

9.5 Weight Cart Cleanliness

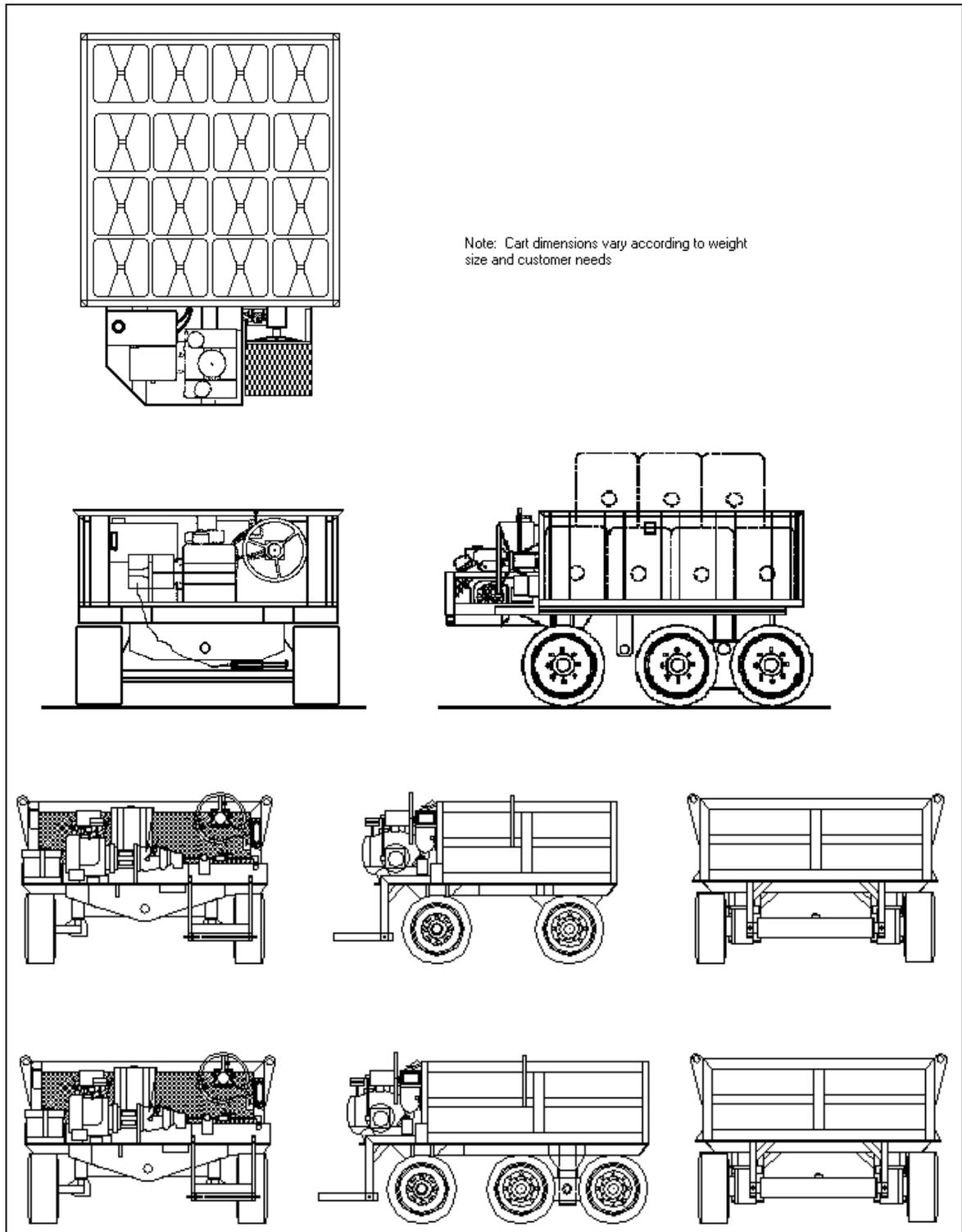
The weight cart shall be maintained free of all visible contamination; this includes but is not limited to: mud, lubricants, water or product being weighed.

9.6 Licensing of Weight Cart Operators

According to the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) web page, a weight cart may be considered to be a Powered Industrial Truck. Owning organizations and operators must contact the local office of OSHA for a written determination of the weight cart status. More information can be obtained from: OSHA, Directorate of Safety Standards Programs; U.S. DEPARTMENT OF LABOR; Room N3621; 200 Constitution Avenue, N.W; Washington, D.C. 20210. Telephone (202) 693-2082; FAX (202) 693-1663. If the weight cart is designated a Powered Industrial Truck, the operator must complete an operator training course, and a daily safety inspection and checklist are required. A sample checklist is provided as Attachment 2.

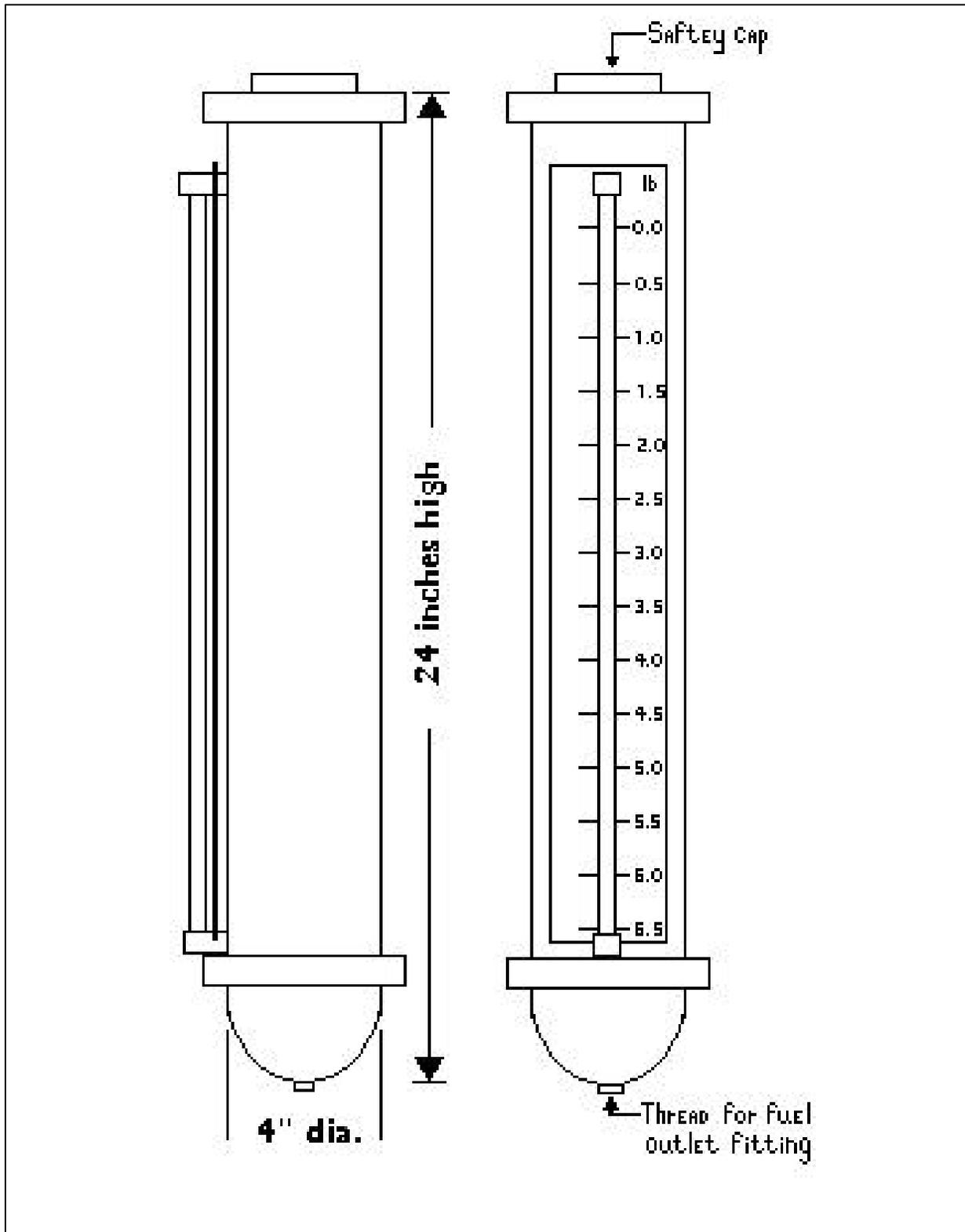
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Figure 1
Typical Weight Cart Configurations



Typical configurations of a liquid fueled weight cart with up to 6 000 lb net weight and up to 37 500 lb gross weight.

Attachment 1 Example Fuel Tank Drawing



Attachment 2

Example Daily Weight Cart Inspection Checklist

Weight cart identification number	
Weight cart manufacturer	
Weight cart model number	
Weight cart serial number	

Walk Around				
	(OK)	(Inspection starts at operator platform)	Needs Attention	Date Corrected
1.		No evidence of metal fatigue on cart structure (e.g. cracks)		
2.		No evidence of fluid leaks		
3.		Tire Integrity (e.g. major nicks, cracks, cuts contamination)		
4.		Wheels secured		
5.		Major components secured in place (e.g. Engine, battery, fuel tank, hydraulic pump)		
6.		Engine oil level correct and oil not grossly contaminated		
7.		Hydraulic oil level correct and oil not grossly contaminated		
8.		Operator platform level and securely attached		
9.		All guards and shields in place and secure		
10.		Steering components securely attached		
11.		All lead and wire seals in place		
12.		Fuel tank filled to proper level		
13.		All labels and decals in place		

Operational checklist				
	(OK)	(Start weight cart motor and test controls)	Needs Attention	Date Corrected
1.		Engine starts and operates properly		
2.		Steering mechanism works properly		
3.		No fluid leaks		
4.		Forward/reverse controls functioning properly		
5.		Strobe lights functional (if equipped)		
6.		Rail gear functional (if equipped)		